Figure 1: Delay-and-Weight Beamforming

$$\begin{cases} \Delta OPL = \Delta n * L \\ \Delta OPL = n * \Delta L \end{cases}$$
$$\Rightarrow \quad \Delta OPL = \Sigma_i$$
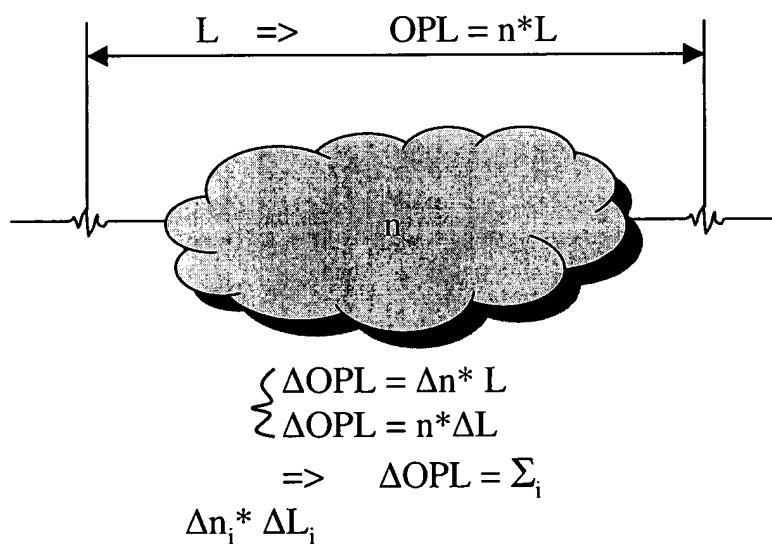$$\Delta n_i * \Delta L_i$$

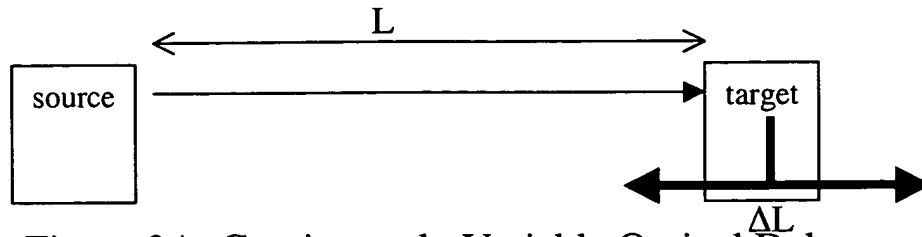Figure 2. Optical path length (OPL) and its variation

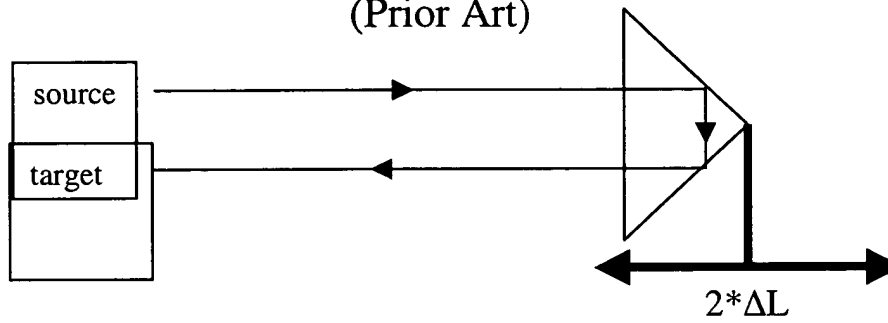Figure 3A: Continuously Variable Optical Delay
(Prior Art)

Figure 3B: Continuously Variable Optical Delay
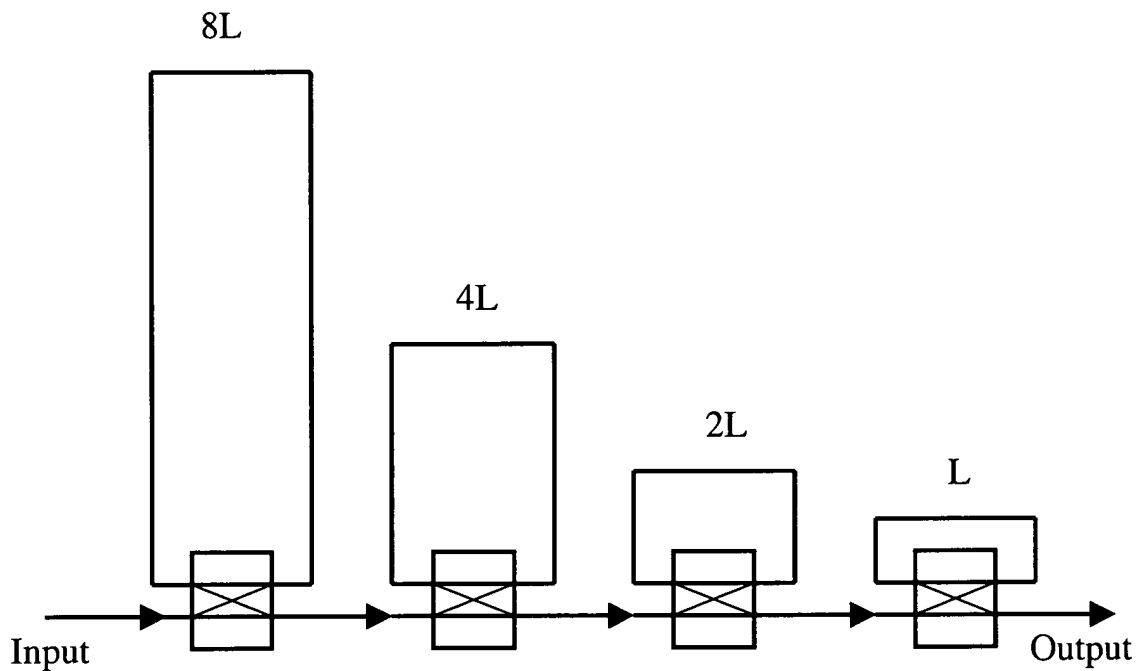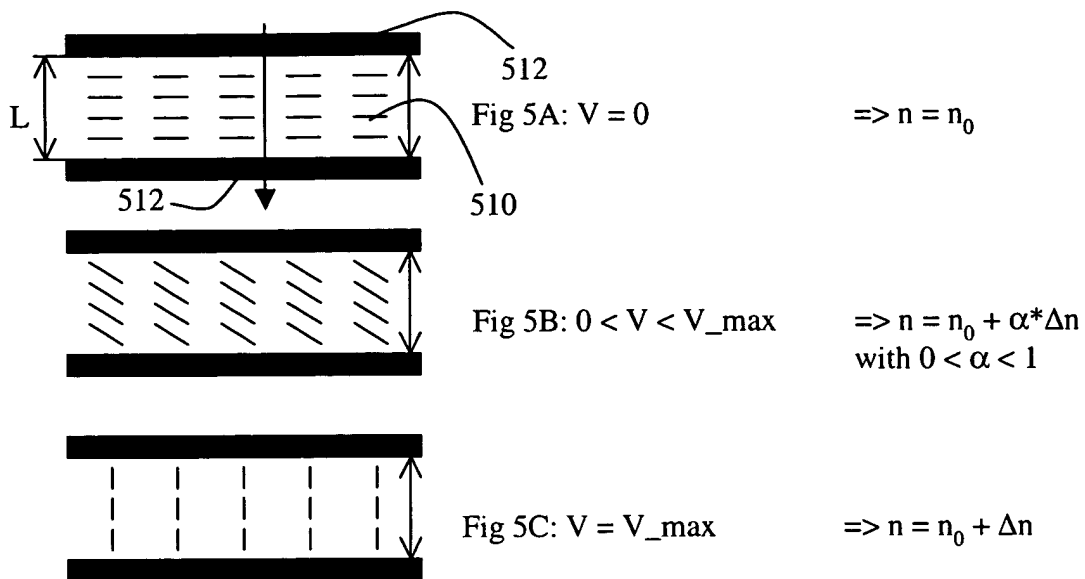with folded optical paths
(Prior Art)

Figure 4: Discretely Variable Optical Delay using Optical Manifolds
(Prior Art)

L

512

Fig 5A: V = 0   => $n = n_0$

512   510

Fig 5B: 0 < V < V_max   => $n = n_0 + \alpha * \Delta n$
                                      with $0 < \alpha < 1$

Fig 5C: V = V_max   => $n = n_0 + \Delta n$

Dynamically variable optical delay: $\Delta OPL = \alpha * \Delta n * L$

Figure 5

(1/n) L 620

(1/n)   622
                 $2*L$

$\Delta OPL\_max = \Sigma_i \, \Delta n_i * L_i$
                          $= (n-1)*(1+2+4 \dots 2^n)*L$

$\Delta OPL\_min = 0$

624

(1/n)

2^n*L

Air/Liquid injection
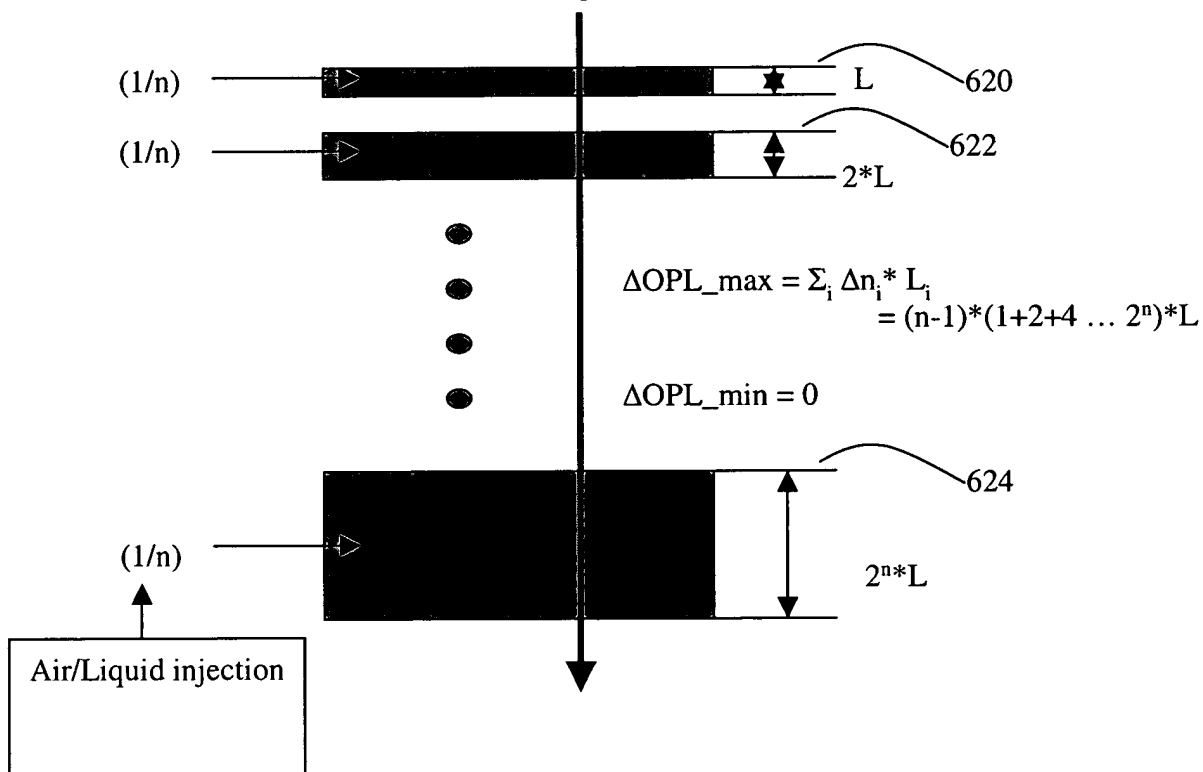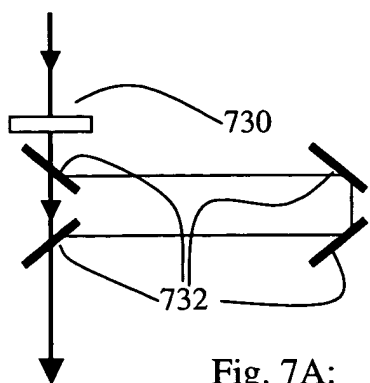
Figure 6

Fig. 7A:
Pass-through path

Fig. 7B:
Folded path

Polarizing Beam Splitter (passive) 732
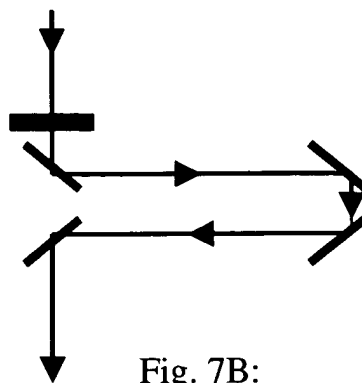
Input

LC Polarization Rotator (active) 730

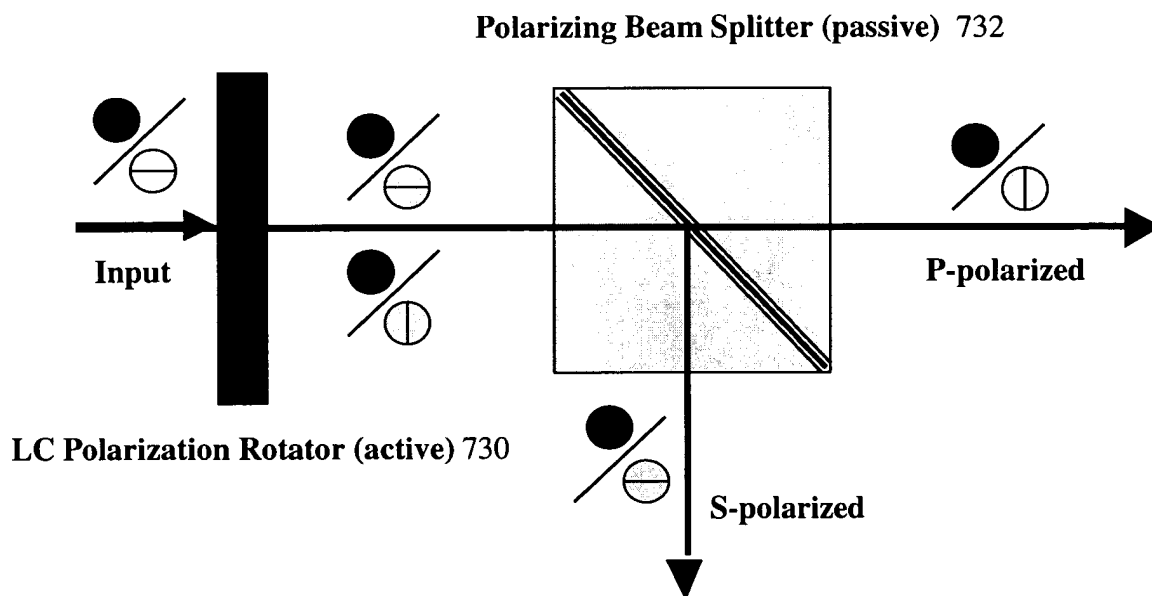P-polarized

S-polarized

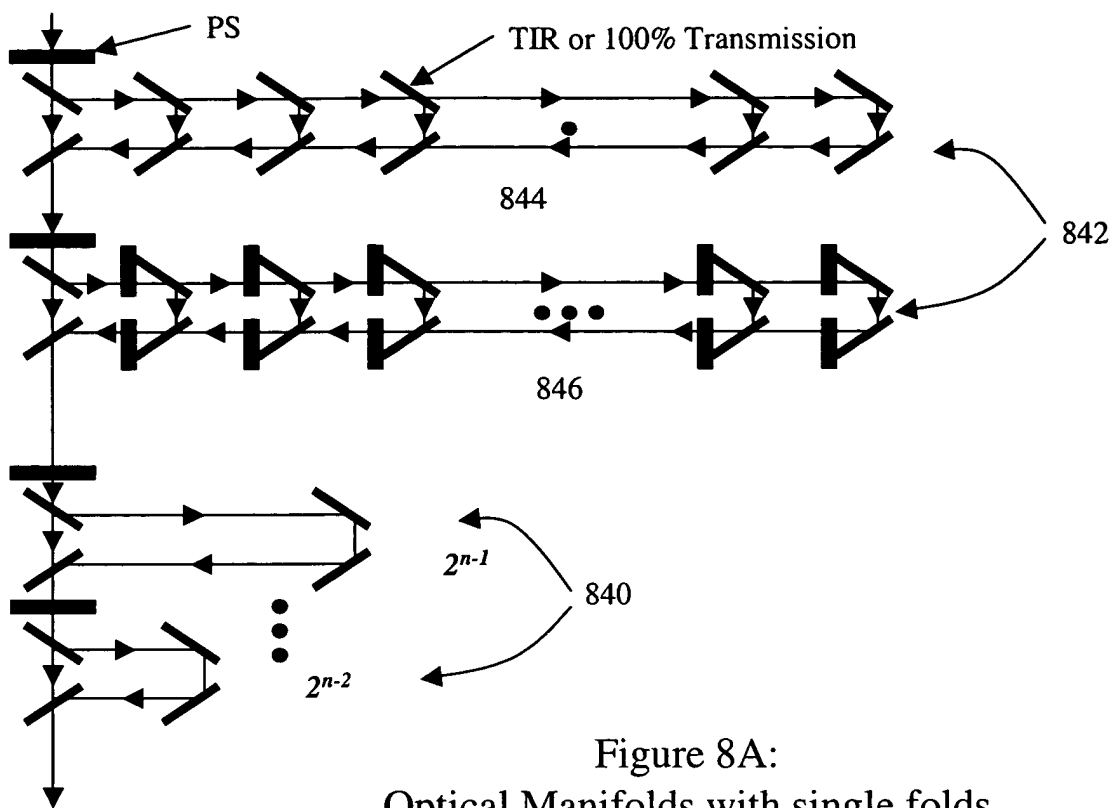Fig. 7C: LC polarization optical switch

Figure 8A:
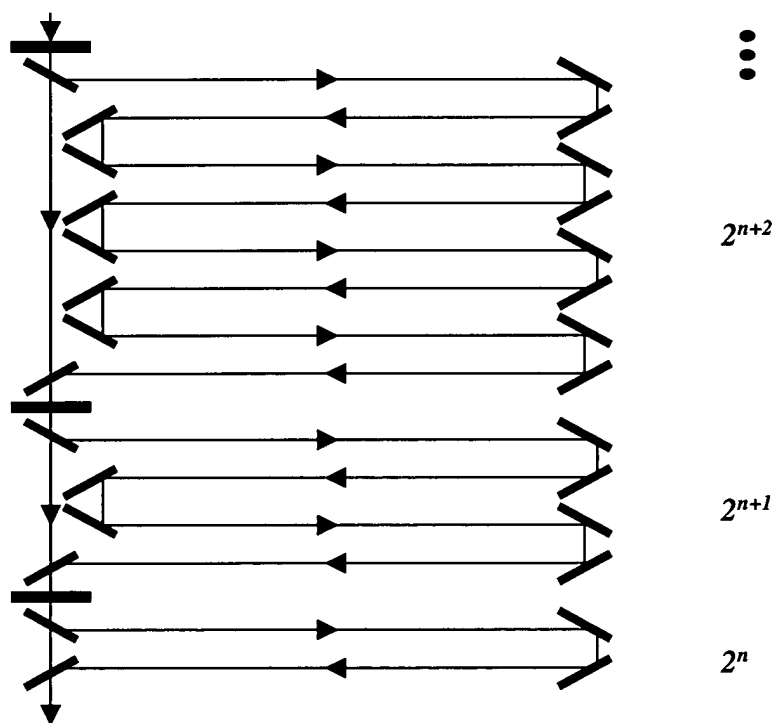Optical Manifolds with single folds

Figure 8B
Optical manifolds with multiple folds

Figure 8C
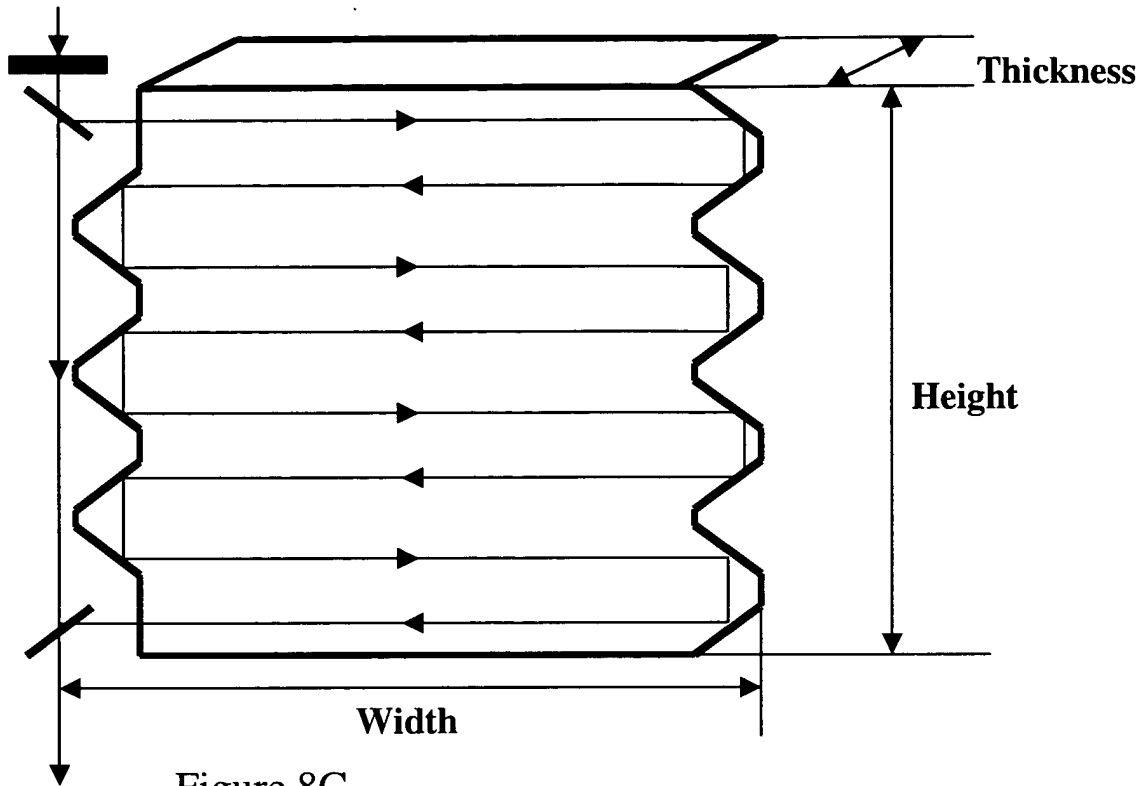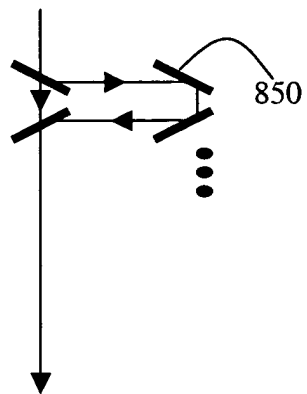Molded optical manifolds

Figure 8D: Micro-Fluidic Variable Optical Delays
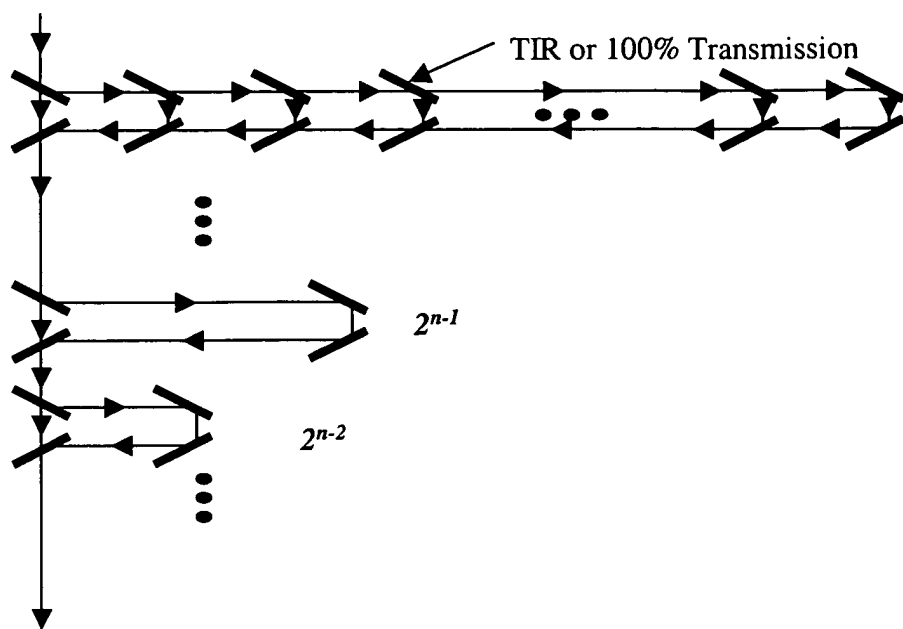
TIR or 100% Transmission

2^{n-1}

2^{n-2}

Figure 8E: Micro-Fluidic Optical Manifolds
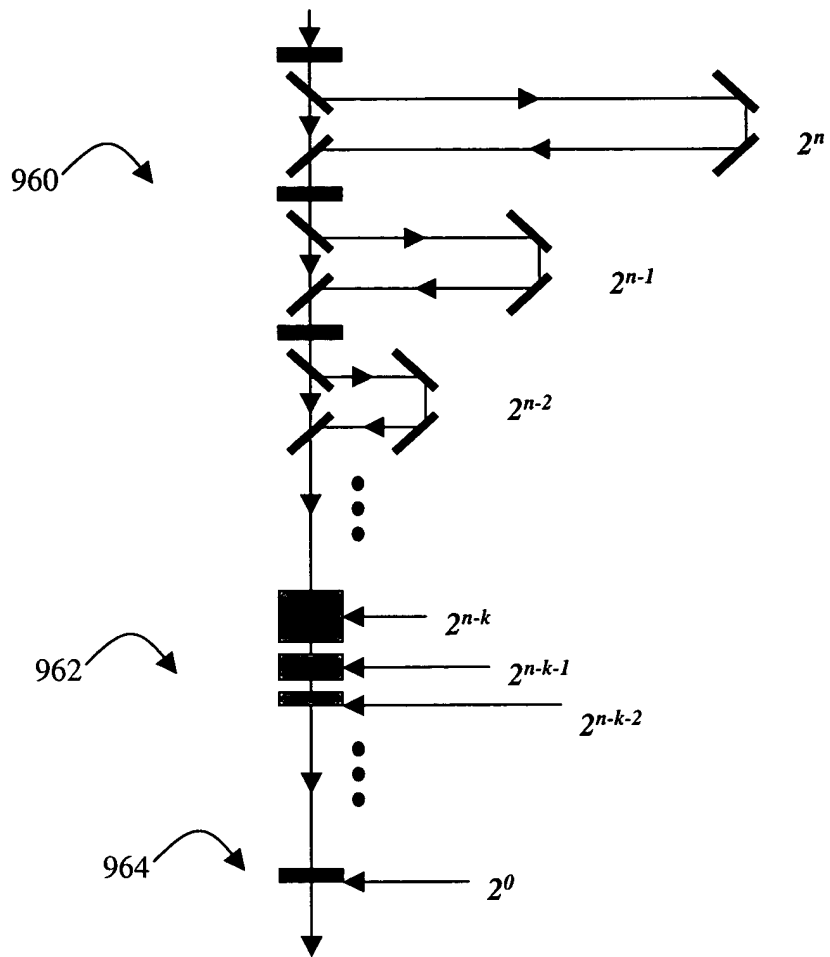
Figure 9: VOD with Coarse and Fine Delays
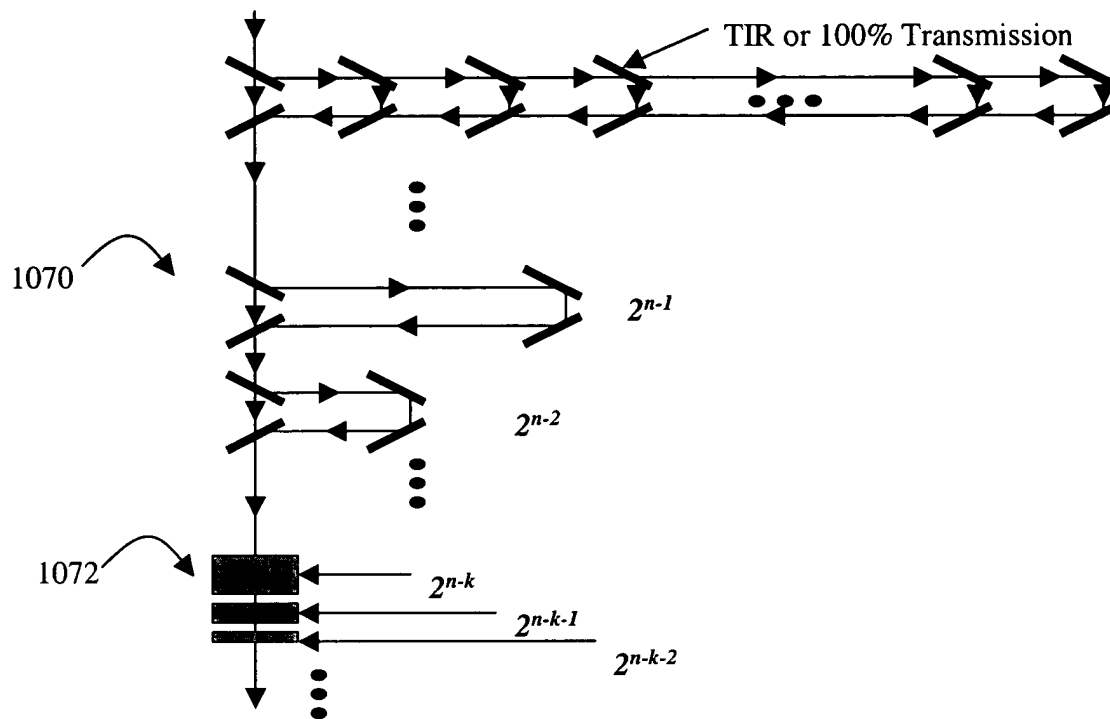
Figure 10: All-Micro-Fluidic Variable Optical Delays

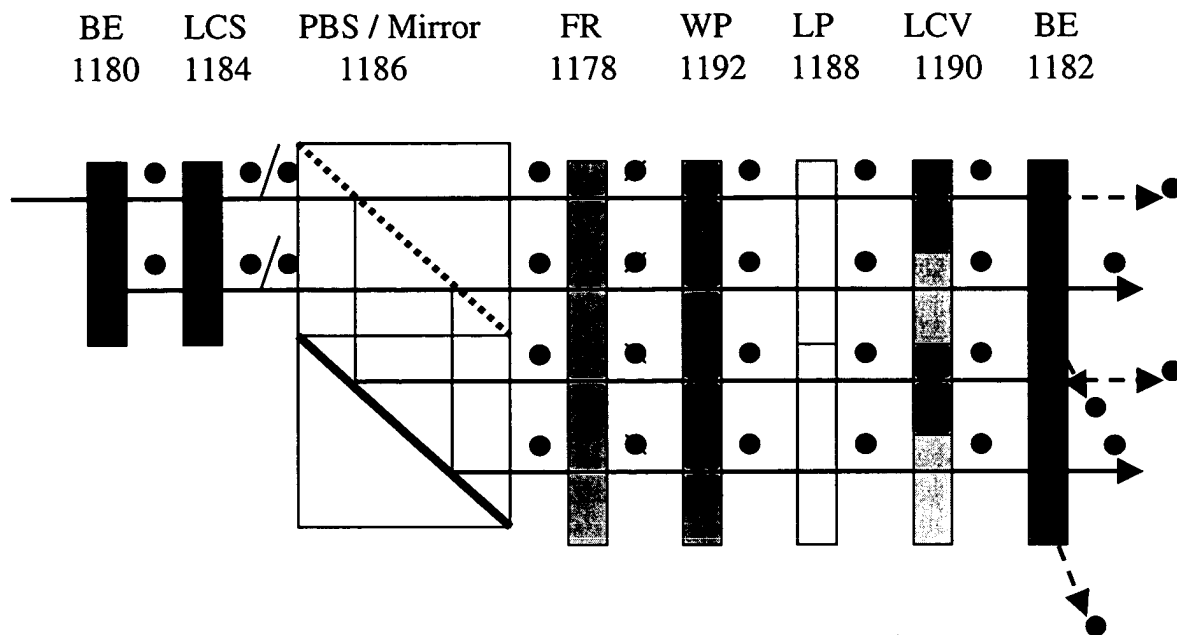| BE	LCS	PBS / Mirror	FR	WP	LP	LCV	BE
1180	1184	1186	1178	1192	1188	1190	1182

Figure 11A: Optically Isolated
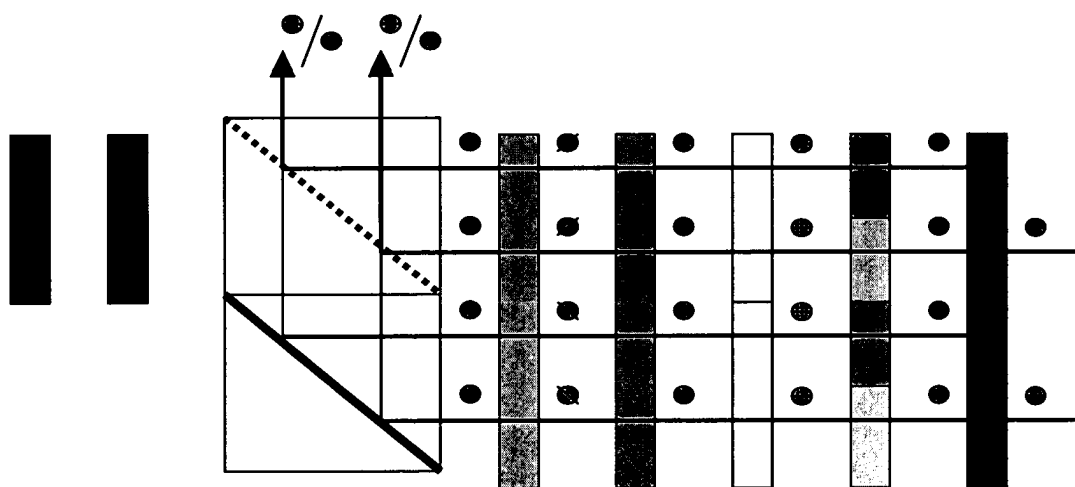VOA and 1x2 Optical Switch-
Forward Propagation

Figure 11B: Optically Isolated
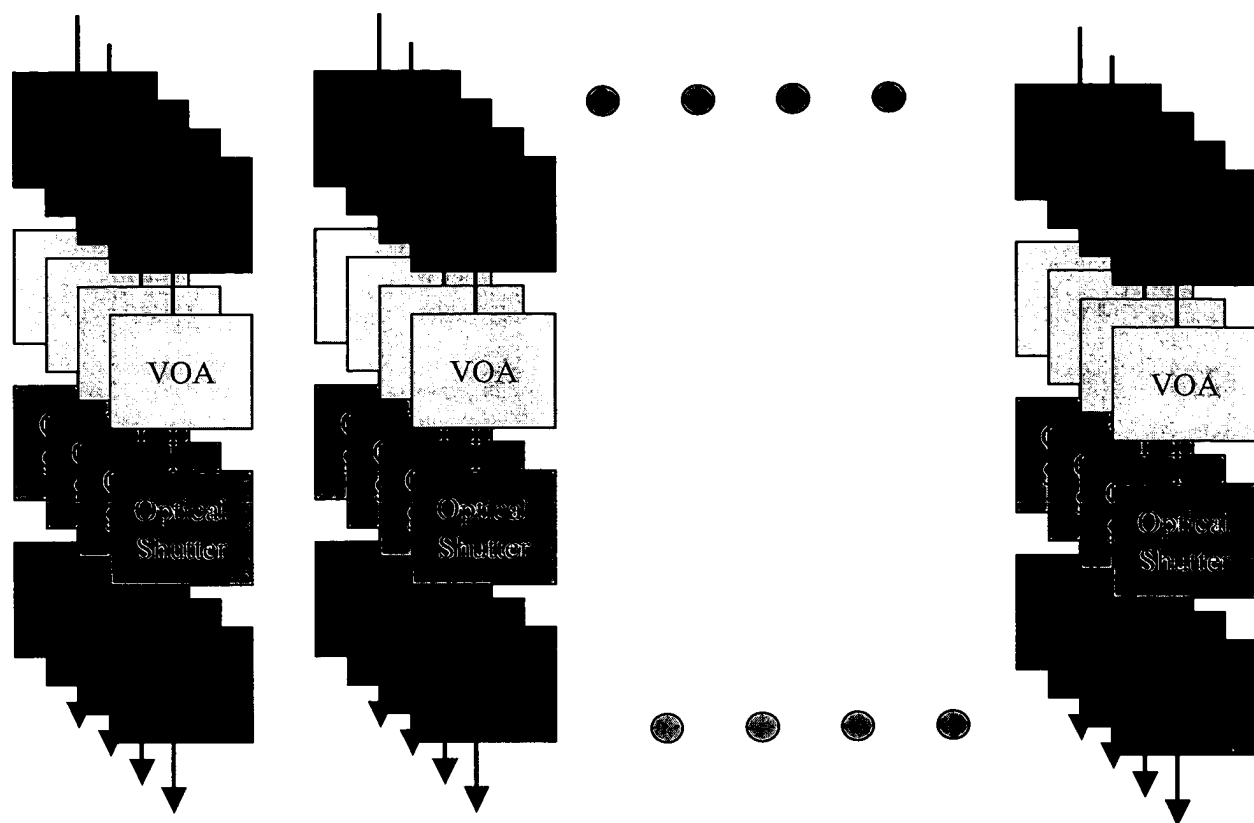VOA and 1x2 Optical Switch-
Backward Propagation

Figure 12: Massively-Parallel Analog
Optical Processing Module Using Arrayed VOD